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ABSTRACT

Separate meta-analyses have been completed recently on the effectiveness of computer-based education (CBE) in elementary schools, high schools, colleges, and nontraditional postsecondary institutions. Several conclusions can be drawn from these meta-analyses. First, although CBA has not been uniformly successful in all its guises and at all instructional levels, most CBE programs have had the following positive effects on students: students have learned more and retained more in courses providing assistance from computers; students learned their lessons in less instructional time and liked their classes more when they received computer help; and students developed positive attitudes towards computers when they received help from them in school. Second, results of CBE vary as a function of the evaluation design used to measure CBE effectiveness; and third, study outcomes also vary as a function of the type of publication in which the results are found. Since CBE generally has positive effects on student learning, future programs of implementation and development should be encouraged. Research is needed, however, to determine the factors that produce differences in the results of studies reported in journals and in dissertations, and differences in the results of studies using different research designs. (Author/JB)

Consistencies in Findings
On Computer-Based Education

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Abstract

Separate meta-analyses have been completed recently on the effectiveness of computer-based education (CBE) in elementary schools, high schools, colleges, and nontraditional postsecondary institutions. Several general conclusions can be drawn from these meta-analyses. First, CBE programs usually have positive effects, as measured by several different criteria of instructional effectiveness. Effects are not uniformly, high, however, for all types of CBE programs at all instructional levels. Second, effects vary as a function of the evaluation design used to measure CBE effectiveness. And third, study outcomes also vary as a function of the type of publication in which the results are found.

Consistencies in Findings on Computer-Based Education

Many people believe that computer technology will transform society in the years ahead as completely as the invention of the printing press did 500 years ago or as the invention of writing did thousands of years ago. Like these earlier inventions, computer technology gives society a new way of encoding, storing, and retrieving information. And it therefore seems destined to have pervasive and lasting effects on our professional and our personal lives. Although a few years ago it seemed that future generations would remember the 20th century as the atomic age, it now appears more likely that they will remember our times as the computer age.

Educational researchers and developers therefore are no longer asking whether a computer revolution will occur in education. They are asking instead how it will occur. Will the changes in education come swiftly and smoothly, or will education's transition to the computer age be full of false starts and costly mistakes? No one asked such questions when the revolutions based on writing and printing were taking place because they had no good ways of finding reliable answers. Researchers are asking these questions now because they know that the tools of social science are available to help them reach conclusions about computer technology's effects. Social scientists have a rare opportunity to measure these effects, predict future results, and help control developments at a critical point in the history of education.

During the past two decades, a number of researchers have used the methods of the social sciences to evaluate computer-based teaching. My colleagues and I recently joined this effort because we believe that adapting to the computer age is one of the major challenges facing schools today. But what is the yield from twenty years of research? Do we know anything now that we did not know before? The purpose of this paper is to describe and interpret the most important findings.

RESULTS

We have described the major results at length in other places (Bangert-Drowns, J. Kulik, & C. Kulik, in press; C. Kulik & J. Kulik, 1985; C. Kulik, J. Kulik, & Shwalb, 1985; J. Kulik, C. Kulik, & Bangert-Drowns, in press). What follows is a summary and integration of results reported there.

Overall results. Most CBE programs have had positive effects on students (Table 1).

(a) Students have generally learned more in classes when they have received help from computers. The average effect of computers in all 199 studies used in our meta-analyses was to raise examination scores by 0.31 standard deviations, or from the 50th to the 61st percentile.

(b) Students remembered what they learned longer. The average effect of CBE in 18 followup or retention studies was to raise examination scores by 0.17 standard deviations.

(c) Students also learned their lessons with less instructional time. The average reduction in instructional time in 28 investigations of this point was 32%.

(d) Students also liked their classes more when they received computer help. The average effect of CBE in 17 studies was to raise attitude-toward-instruction scores by 0.28 standard deviations.

(e) Students developed more positive attitudes toward computers when they received help from them in school. Average ES in 17 studies on attitude toward computers was 0.33.

(f) Computers did not, however, have positive effects in every area in which they were studied. The average effect of CBE in 29 studies of attitude toward subject matter was near zero, and the average effect was also near zero in 23 studies of course completion.

Type of computer use and instructional level. CBE was not uniformly successful in all its guises and at all instructional levels (Table 2). Effects of computer-assisted instruction (CAI), computer-managed instruction (CMI), and computer-enriched instruction (CEI) were different at different instructional levels.

(a) In elementary schools, for example, CAI programs almost always produced good results, raising student achievement scores in the typical case by 0.47 standard deviations. CMI programs, on the other hand, produced much weaker effects, raising student achievement in the typical case by only 0.07 standard deviations. No adequate evaluations of CEI programs in elementary schools turned up in our literature searches.

(b) In high schools, the pattern of findings was quite different. CMI had the most to contribute at this

level, and CEI had the least to contribute. CAI produced effects that were intermediate in size.

(c) In colleges and adult settings, CAI, CMI, and CEI were all effective. Young adults and older adults seem able to profit from a variety of different uses of the computer in teaching.

Study features and study outcomes. A few study features were consistently related to outcomes of evaluations of computer-based education (Table 3).

(a) Study results were consistently stronger in published studies and weaker in unpublished ones. The average effect of CBE in published studies was to raise student examination scores by 0.46 standard deviations, whereas its average effect in unpublished studies was to raise scores by only 0.23 standard deviations.

(b) Effects were consistently larger in short studies and weaker in longer ones. The average effect of CBE in short studies was to raise examination scores by 0.36 standard deviations, whereas the its average effect in longer studies was to raise scores by 0.27 standard deviations.

(c) Effects tended to be larger in more recent studies and smaller in older studies. The average effect of CBE in studies published before 1975 was to raise examination scores by 0.24 standard deviations; the average effect in studies published in later years was a score increase of 0.36 standard deviations.

(d) Effects tended to be larger when different teachers taught the experimental and control groups. Effects were smaller when the same teacher was responsible for both groups. With the same teacher in charge of experimental and control groups, average size of effect on examination scores was 0.24 standard deviations. With different teachers in charge of the groups, the average effect was 0.40 standard deviations.

DISCUSSION

Can we conclude from these findings that the computer has the potential to add something important to education? Some critics have argued from these findings that the computer is not the active ingredient in these outcome studies. Other factors have been invoked to explain--or explain away--the positive findings: editorial gatekeeping, novelty factors, and uncontrolled teacher effects.

Editorial gatekeeping. Some critics believe that results in unpublished reports are more accurate than results in journals because unpublished results have not been distorted by editorial gatekeeping. This is the purported tendency of researchers, reviewers, and editors to base publication decisions on size and statistical significance of effects rather than on study quality.

The critics are correct in noting that results differ in published and unpublished studies. It should be noted, however, that published and unpublished studies differ from each other in some other ways too. The authors of journal and dissertation studies, for example, differ from one another in their research experience, in their resources, in their relationship to instructional developers, and in many other respects. Such differences can explain--just as well as publication bias does--the differences in results found in dissertations and journals. It seems to us that we know too little about what lies behind the difference in journal and dissertation results to reject out-of-hand either kind of result.

Novelty effects. Stated simply, the novelty hypothesis says that the novelty of CBE contributes a good deal to its effects on students. One prediction from this hypothesis is that effects will be greater in short studies and smaller in long ones. This is, in fact, the way the results come out. Short studies of CBE reported more positive results than did long studies: the average ES in short studies was 0.34, and the average ES in long studies was 0.26. Critics have interpreted this finding to mean that CBE is effective in raising achievement only while students find it novel. With familiarity, CBE loses some of its potency.

It is important to note that our overall conclusions about CBE effectiveness would not be very different if we based them on the short-term studies alone or on the long-term studies. But it is not obvious to us that one set of studies is clearly better than the other. The long-term studies provide a better control for novelty effects, but the short-term studies may provide a better control over other extraneous factors. In short studies, for example, criterion tests may measure more exactly the material taught by the competing methods.

It is also important to note that another prediction can be made from the novelty hypothesis. And that is that CBE will become less effective as computers become more common in society. This prediction is not supported by our analysis. CBE has become more effective over the years--perhaps as a function of improvements in computer software, hardware, and courseware.

Experimental design. Critics have also suggested that apparent CBE effects may be produced by other uncontrolled differences in the treatment of experimental and control groups. One indicator that such differences are important, these critics believe, is the relationship reported in a number of meta-analyses between effect size and the use of the same versus different instructors for the experimental and control treatments in a study. When the same instructor teaches experimental and control treatments, effects are often smaller; when different instructors are responsible for experimental and conventional teaching, effects are often larger.

Why should one-instructor and two-instructor experiments produce somewhat different results? It is not at all obvious to us. It may be, for example, that in two-instructor experiments, the poorer instructor is usually assigned to the control condition and the better instructor to the experimental condition, and the difference between conditions is magnified because of these teacher assignments. If this is the case, then one-instructor studies more accurately assess the effects of CBE. It may also be, however, that in one-instructor studies there is diffusion of the innovative treatment to the control condition. Involvement of a teacher in an innovative approach to instruction may have a general effect on the quality of the instructor's teaching. Outlining objectives, constructing lessons, preparing evaluation materials, and working with computer materials--requirements in CBE--may help a teacher to do a better job in a conventional teaching assignment. If this is the case, two-instructor studies provide the better basis for estimating the size of an experimental effect.

CONCLUSIONS

Among the conclusions that can be drawn from CBE outcome studies, we believe that the following are especially important:

(a) Most CBE programs have had positive effects on student learning. Future programs of implementation and development of CBE for schools should therefore be encouraged. If such programs are as carefully designed as present implementations are, they will most likely produce positive results.

(b) CBE has not been uniformly successful in all its guises and at all instructional levels, however. Elementary schools have had a good deal of success in increasing student achievement through CAI programs; they have had less demonstrable success with CMI and CEI. Secondary schools have had success with CAI and CMI but less

success with CEI. College and adult courses have benefited moderately from CAI, CMI, and CEI. Future programs of implementation and development should also take these findings into account.

(c) Both journal articles and dissertations present a basically positive picture of CBE effectiveness, but the findings reported in journal articles are clearly more favorable. Research is badly needed to determine the factors that produce differences in journal and dissertation results because such differences have been found in a number of different areas in social science research. Does editorial gatekeeping lead professional journals to present a distorted picture of social science findings? Or do dissertation authors simply measure experimental effects less well than do more seasoned researchers?

(d) Although a variety of different research designs can be used to show the effectiveness of CBE, certain research designs seem to produce more positive results. Studies where the same instructor teaches both experimental and control classes, for example, report somewhat weaker effects than do studies with different experimental and control teachers. Studies of long duration often report weaker effects than do short studies. Reasons for the difference in results from studies using different experimental designs are imperfectly understood, however. Research on such factors should be encouraged.

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Table 1

Average Effect of CBE on Students

In 199 Studies

Outcome Measure	Number of Studies	Average Effect*
Final examination	199	0.31
Follow-up examination	18	0.17
Attitude toward instruction	17	0.28
Attitude toward computers	17	0.23
Attitude toward subject	29	0.05
Course completion	23	-0.06
Instructional time	28	68%

*The average effect is measured by the statistic <u>ES</u> for the following variables: final examination; followup examination; attitudes toward computers, instruction, and subject matter. Effects were measured by the statistic <u>h</u> (Cohen, 1977) for course completion. Savings in instructional time were measured in percentage of time saved (x/c).

Table 2

Average ES for Different CBE Implementations at Different Instructional Levels

Instructional Level	Type of CBE Implementation					
	CAI		CMI		CEI	
	N	ES	N	ES	N	ES
Elementary	29	0.47	4	0.07	0	--
Secondary	17	0.36	9	0.40	16	0.07
College	58	0.26	13	0.35	28	0.23
Adult	18	0.29	3	0.72	2	1.13

Note: CAI is computer-assisted instruction; CMI is computer-managed instruction; CEI is computer-enriched instruction.

Table 3

Average ES for Final Examinations

By Study Feature

Study Feature	Number of Studies	Average ES
Publication Source		
Published	65	0.46
Unpublished	131	0.23
Duration of instruction		
Less than 9 weeks	79	0.36
9 weeks or more	114	0.27
Publication year		
Before 1975	92	0.24
1975 and after	104	0.36
Control for instructor effect		
Control present	100	0.24
No control	86	0.40